YELLOW VINE DISEASE OF WATERMELON AND CANTALOUPE IN TEXAS AND OKLAHOMA

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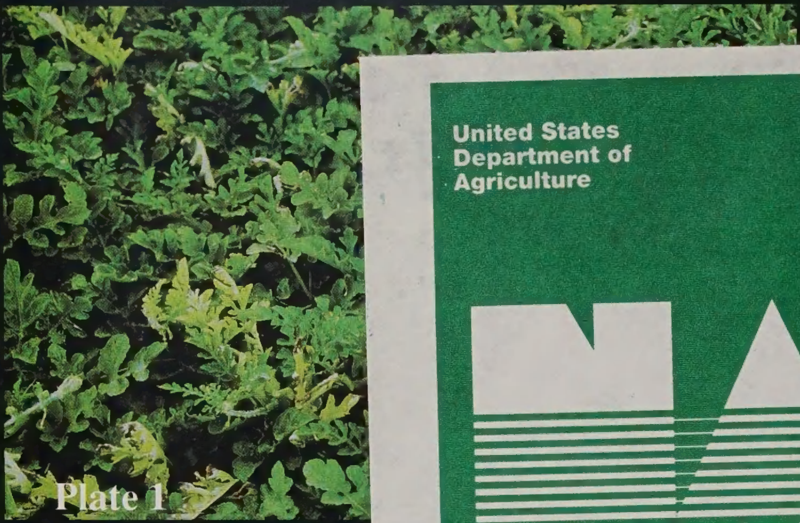

Plate 1

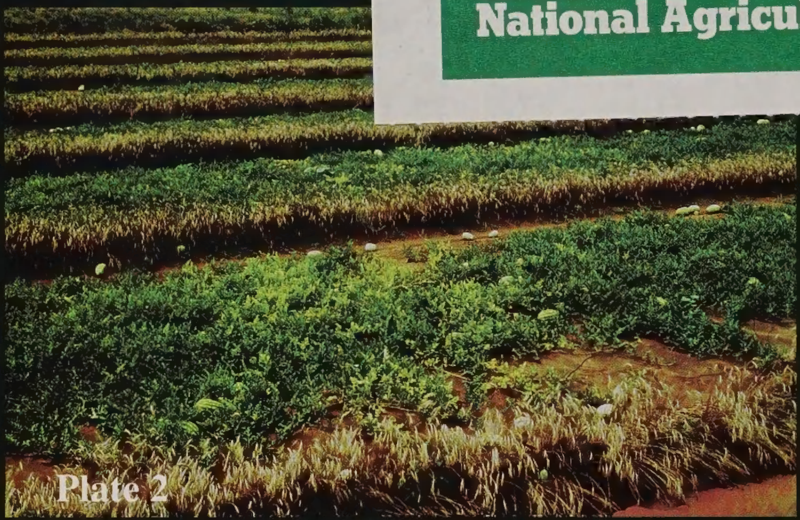

Plate 2

Plate 6

Plate 3

Plate 7

Plate 4

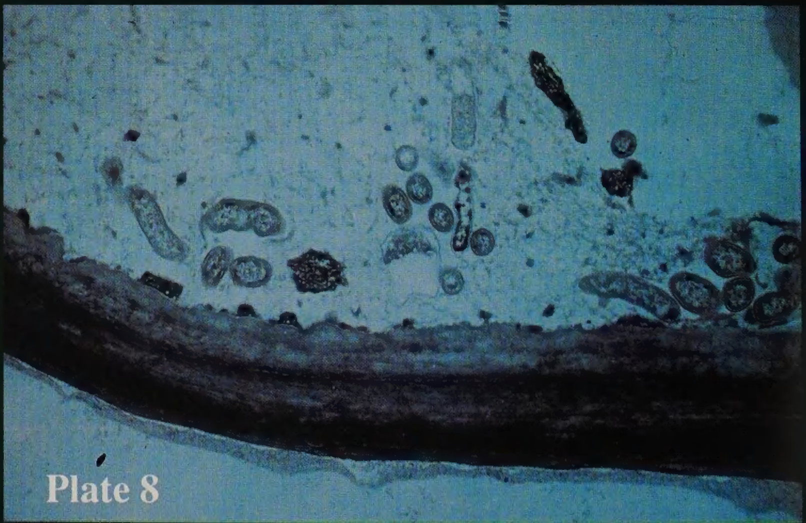

Plate 8

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Cover Page Photos

Upper Left: Yellow vine of squash (Lane, OK).
Upper Right: Yellow vine of watermelon (DeLeon, TX).
Lower Right: Total loss of 80 acre watermelon field due to yellow vine (Rush Springs, OK).
Lower Left: Yellow vine of cantaloupe (Courtney, OK).
Center: U. S. Department of Agriculture, South Central Agricultural Research Laboratory (Lane, OK).

Inside Cover Photos

Plate 1: Initial symptoms of yellow vine in watermelon.
Plate 2: Intermediate stage of yellow vine symptoms in watermelon.
Plate 3: Yellow vine of watermelon showing vertical position and curling of leaves.
Plate 4: Final stage of yellow vine disease in watermelon.
Plate 5: Yellow vine of watermelon showing phloem discoloration.
Plate 6: Fusarium wilt of cantaloupe showing xylem discoloration.
Plate 7: Fusarium wilt of cantaloupe illustrating lesion on one side of stem.
Plate 8: Bacterialike organism in phloem of cantaloupe affected with yellow vine disease.

Back Cover

Aerial photo of Courtney, OK field. Note patches of watermelon affected with yellow vine disease.

FOREWORD

This information is presented to assist growers, extension personnel, and others involved in the cucurbit industry.

ACKNOWLEDGEMENTS

Numerous people from many state and federal agencies, extension personnel, farm organizations, and farmers themselves have made many significant contributions to the yellow vine project over the years.

INTRODUCTION

Cucurbit crops are susceptible to many soil-borne plant pathogens that can cause serious yield losses. Of these, Fusarium wilt has notoriously been one of the most prominent soil-borne diseases of watermelon. Satisfactory control of the disease can be obtained by using moderately to highly race 1 resistant cultivars and a six-year rotation (Hopkins and Elmstrom, 1984). More recently, a highly virulent isolate of Fusarium oxysporum f. sp. niveum race 2 was reported in Texas, Oklahoma, and Florida (Martyn and Bruton, 1989). There is no resistance to this race in any of the commercially acceptable watermelon cultivars. At present, race 2 does not appear to be widespread, even in the states where it has been reported. F. o. f. sp. niveum is generally considered to be host specific, although Martyn and McLaughlin (1983) demonstrated in greenhouse studies that race 1 was capable of inducing wilt in some yellow and zucchini squash cultivars equal to the watermelon control. McMillan (1986) reported that Fusarium isolates, from diseased watermelon and cucumber in the Bahamas, were capable of cross-infection and causing wilt in both crops. Specific information is not available on field reaction of cucurbits to F. o. f. sp. niveum race 2.

Although, Fusarium wilt is important in some cantaloupe growing areas, it appears to be a relatively minor problem in Texas and Oklahoma. In 1980, vine decline caused by Macrophomina phaseolina was the predominant soil-borne disease of cantaloupe in South Texas (Bruton et al., 1987; Bruton et al., 1988b). By 1984, hybrid cultivars with resistance (tolerance)(Bruton and Wann, 1995) to M. phaseolina had replaced standard cultivars such as Perlita and TAM-Uvalde in the Lower Rio Grande Valley. By 1985, a root rot/vine decline caused by Monosporascus cannonballus was the predominant soil-borne disease of cantaloupe (Mertely et al., 1991). M. cannonballus may have caused some damage as early as 1982 at the USDA-ARS Research Center in Weslaco, TX, although the disease was not identified (Bruton and Miller, unpublished data).

In 1988, an unusual disease called yellow vine of squash and pumpkin was observed in Oklahoma (Cartwright and Bruton, 1993). The causal agent was not identified. A similar, if not identical, disease was subsequently observed in watermelon and cantaloupe in Central Texas and Oklahoma in 1991 (Bruton et al., 1993). No fungal, viral, or prokaryotic pathogens were consistently associated with the yellow vine disease (Shaw et al., 1993). Based on aggregation of diseased plants (Duthie et al., 1993) and a reduction of yellow vine in insecticide-treated plots (Cartwright and Bruton, 1993), insects seemed to have a direct association, either as a stress factor or vector of the disease. The purpose of this paper is to: 1) compare and contrast symptoms of yellow vine with various cucurbit vine declines that exhibit similar symptoms and 2) review completed work to date on the status of yellow vine, and 3) outline ongoing research on the disease.

SYMPTOMS OF YELLOW VINE

Symptoms of yellow vine are essentially the same in squash, watermelon, and cantaloupe (cover page). In some cases, immature plants may not turn yellow but wilt and collapse in one day. There is no recovery at night, as is often seen in plants affected by Fusarium wilt. The

incidence of the rapid collapse in immature watermelon plants is generally much less than the yellow vine phase on mature plants. The immature plant collapse tends to be much worse in cantaloupe. Normally, symptoms begin to appear as the fruit approaches maturity (10-15 days before harvest). With experience, diseased watermelon and cantaloupe plants can be detected a few days prior to their turning yellow. Leaves on the entire plant change color ranging from a lime-yellow to bright yellow (Plate 1). When the plant starts turning yellow, it's a fairly rapid process taking only 2-3 days to become completely chlorotic (Plate 2). Fruit and flowers on affected plants are not distorted but fruit do tend to lose their chlorophyll very quickly, especially in watermelon.

Internodes are greatly reduced in the terminal 20-30 cm and the leaves stand in a vertical position, especially in watermelons (Plate 3). Leaves on the stem terminals of affected plants do not expand properly with the outer perimeter of the leaf curling inward. Seven to ten days after first symptoms appear, most of the leaves are dead giving a blighted appearance (Plate 4) except for the terminal leaves on individual runners. At this stage, yellow vine can be easily confused with several other vine decline diseases. However, in contrast to many vine declines, there are no crown lesions associated with yellow vine. One symptom that is consistently present and associated with yellow vine is phloem discoloration (Plate 5). Phloem discoloration may extend from the roots throughout the plant, but it is most intense in the root and crown area. Root rot is not associated with the early onset of yellow vine. In fact, the root system typically appears disease free. In the later stages of yellow vine, the root system does begin to deteriorate rapidly. It is at this stage that yellow vine could be easily confused with a number of the soil-borne diseases associated with other vine declines of melons.

The one disease that has been occasionally confused with yellow vine is Fusarium wilt (Plate 6). Therefore, a description detailing symptoms of both diseases seems appropriate. Disease identification in the field can often be extremely difficult. One reason is that more than one disease can be occurring at the same time within a field. To make matters worse, individual plants are often affected by two or more diseases. One concept that should be kept in mind is that the "typical" or "classic" symptom is not always the predominant symptom. There are generally a range of symptoms associated with particular diseases that are used collectively for field identification. Therefore, many plants should be examined to get an adequate picture of the disease situation.

Fusarium wilt symptoms of cantaloupe and watermelon are essentially identical. Under some circumstances, the fungus causing Fusarium wilt can cause a seedling disease, but this is not relevant to confusion with yellow vine. Normally, Fusarium wilt begins to appear as the vines become large and fruit near maturity. However, Fusarium wilt can occur anytime after the plant starts vining. Affected plants may remain dark green or they may yellow slightly, particularly in the crown leaves. The more "classic" symptom of Fusarium wilt is a rapid wilting during the heat of the day. The plants often will recover at night. This can reoccur for several days before the plant finally succumbs. Often times, affected plants will exhibit a light to dark brown streak or lesion running along the side of the stem (Plate 7). The lesion may be continuous or intermittent. The discolored lesion may extend for only about 20cm or can extend nearly the length of the vine. In a cross-section of the stem, vascular bundles typically exhibit a dark reddish-brown discoloration running parallel to the lesion with the remaining vascular bundles outside the linear lesion appearing healthy. Secondary runners along the vine that are fed

by the affected vascular bundles may wilt and die. The remaining runners normally appear healthy for several more days until the fungus finally invades all the vascular bundles sufficient to kill the plant. The same symptoms can be observed with the exception that the long linear lesion may be barely detectable. Plants affected by the Fusarium wilt fungus will generally exhibit a dark reddish-brown discoloration of the xylem in the primary root, crown (Plate 6), and extend well along the vine. Plants affected by Fusarium wilt and showing a strong discoloration of the xylem can also exhibit discoloration into the phloem. The xylem discoloration may not always be prominent in all plants. In the initial stages of disease development, root rot is not associated with Fusarium wilt. A note of precaution in disease diagnosis is that plants affected by root rot may often exhibit xylem discoloration, especially in the primary root and crown. Field examination of plants exhibiting the initial symptoms of disease development is critical to an accurate diagnosis.

DISEASE DIAGNOSTIC CHART

A disease diagnostic chart (Fig. 1) is included which should be helpful in field identification of the cantaloupe vine declines. Because not all of these diseases occur in watermelon, it should only be used to differentiate between Monosporascus root rot/vine decline, Acremonium collapse, yellow vine, and Fusarium wilt of watermelons. To use the chart most efficiently, first determine the presence or absence of crown lesions and stem gumming. Second, establish if a root rot is involved in the early stages of disease development. Another pictorial source which should be useful in diagnosis of cantaloupe vine declines is "Atlas of Soilborne Diseases of Melons" (Bruton et al., 1988b).

GEOGRAPHIC DISTRIBUTION

Yellow vine has been found consistently from Central and North Texas through the Central and eastern part of Oklahoma (Fig. 2). During the summer of 1995, yellow vine was observed on watermelons in East Texas (G. L. Philley, personal communication). Examination of photos of diseased plants suggests that the disease may have been present in East Texas in 1978. It has not been observed in the principal melon growing areas of the Rio Grande Valley, Pecos, Uvalde, and Dilley, TX. Furthermore, the disease has not been observed and confirmed northwest of Wichita Falls. In Oklahoma, the disease has been observed in at least one of the susceptible cucurbits throughout the cucurbit growing areas of the state. It may be strictly coincidence, but yellow vine appears to follow a similar geographic pattern as the Cross Timbers Vegetational Area (Fig. 3). The Cross Timbers region is a dominant habitat type or vegetational area throughout much of Central Oklahoma and North Central Texas (Austin, 1965). The region is typically rolling to hilly, dominated by various oaks, elms, pecan, mesquite, and cedar (Correll and Johnston, 1979; Gee et al., 1991). Openings in uplands and bottomlands contain herbaceous vegetation typical of the Tallgrass Prairie region including grasses such as bluestems, switchgrass, and indian grass, as

well as various forbs (Gee et al., 1991). Average annual rainfall is 63.5 to 101.6 cm with the greatest amounts occurring in the months of April, May, and June (Correll and Johnston, 1979).

PLANTING DATE

Planting date with the associated variation in soil temperatures can have a significant impact on disease development in the cucurbits. Late planted watermelons in the Rio Grande Valley can be severely damaged by M. cannonballus (M. E. Miller, personal communication). Gummy stem blight, caused by Didymella bryoniae, seems to be less of a problem at higher temperatures. However, high temperatures tend to increase the incidence of vine decline caused by Macrophomina phaseolina. Planting date has a very pronounced effect on the incidence of yellow vine. Most of the watermelon and cantaloupe growers in Central Texas and Oklahoma transplant or direct seed from the last of March through May. However, a significant number of hectares are planted throughout June and as late as the first week of July. The incidence of yellow vine can approach 100% in some fields which are planted in April and early May. The normal range of yellow vine incidence in early-planted fields is between 20 and 60%. In contrast, melons planted in mid to late June have little or no incidence of yellow vine.

HOST RANGE

In 1988, yellow vine was first observed in Oklahoma on squash and pumpkin. In subsequent field studies, squash, pumpkin, watermelon, cantaloupe, and cucumber were planted in an attempt to determine host range. In those studies, squash and pumpkin were the only cucurbits to develop yellow vine (Cartwright and Bruton, 1993). However, in 1991 yellow vine destroyed large acreages of watermelon in Central Texas and Oklahoma (Bruton et al., 1993). The disease was again present but less severe in 1992. In 1993, yellow vine was nearly non-existent in Oklahoma and only the very early watermelon and cantaloupe plantings in North Central Texas had a severe problem. Yellow vine returned in 1994, particularly on watermelons planted in Central Texas prior to May 15 (R. A. Whitney, personal communication). Disease incidence typically ranged from 5 to 50% in watermelon. Preliminary indications in 1995 are that yellow vine in cantaloupe and watermelon may be severe in Texas and Oklahoma.

From observations over the past eight years, squash and pumpkin clearly appear to be the most susceptible cucurbit to yellow vine. Watermelon is very susceptible as well, but generally the incidence is less than that observed in squash and pumpkin. As far as cantaloupe is concerned, adjacent fields or plantings of cantaloupe and watermelon planted at about the same time, the cantaloupe typically will have 10% or less yellow vine while watermelon may have 50% or more affected vines. However, losses in cantaloupe due to yellow vine can approach 100% at times. Yellow vine has never been observed in cucumber, gourds, or wild cucurbits.

ETIOLOGY

The etiology of yellow vine in the cucurbits has not been resolved. No fungal, viral, or prokaryotic pathogens were consistently associated with cucurbit yellow vine, and inoculations with isolated microorganisms failed to reproduce the symptoms (Shaw et al., 1993). The predominant fungi isolated were Fusarium solani, F. equisiti, F. semitectum, F. oxysporum, Macrophomina phaseolina, Phoma terrestris,and Rhizoctonia solani. Because of the report by McMillan (1986) in which he had isolated a highly aggressive isolate of F. oxysporum that was capable of cross infecting cucumber, cantaloupe, and watermelon, Fusarium wilt was suspected initially, especially in light of the fact that race 2 of the watermelon wilt had recently been reported in Texas and Oklahoma (Bruton et al., 1988a; Martyn and Bruton, 1989). Further investigations using the watermelon races demonstrated that they were capable of cross infecting squash, pumpkin, and watermelon to some degree. However, the evidence indicated that race 2 of the watermelon wilt pathogen was not involved in the yellow vine disease.

A number of other fungi were isolated with some degree of regularity including M. phaseolina. All suspect fungal isolates were either tested for pathogenicity, i.e., F. solani, or discarded as a possible candidate based on a specific knowledge of the pathogen. To date, Monosporascus cannonballus has not been isolated from affected cucurbits in Central Texas or Oklahoma. It is our opinion that M. cannonballus is not involved in the yellow vine disease of cucurbits.

In 1991, lettuce infectious yellows virus (LIYV) was reported infecting cantaloupe and honey dew melons in North Central Texas, watermelon in Central Texas, and squash and cushaw along the upper Gulf Coast of Texas (Halliwell and Johnson, 1992). However, in surveys of Central Texas and Oklahoma from 1991 to present, the white fly (Bemisia tabaci) vector of LIYV has not been detected in melon fields (S. D. Pair, unpublished data). While ELISA tests for beet curly top, LIYV, whitefly transmitted geminiviruses and Spiroplasma citri were largely inconclusive on diseased specimens from Central Texas and Oklahoma, DNA hybridizations or Western Blots were negative (Shaw et al., 1993). No dsRNAs were detected in similar samples sent to Louisiana State University for analysis (R. Valverde, personal communication) further suggesting that viruses were not involved. Affected phloem was positive with Dienes' stain, although samples did not hybridize with clones for mycoplasma like organism (MLO) probes (Shaw et al., 1993). Several insect transmission studies involving numerous insect species have been tested without success (Pair et al., 1993; Shaw et al., 1993). The tests did not exclude any insect species tested as a potential vector due to unknown factors regarding the type of pathogen, vector species, acquisition time, persistence in the vector, latency periods, and vector feeding behavior. Transmission electron microscopy (TEM) of affected plants exhibited pleiomorphic bodies or bacterialike bodies (BLO's) in the phloem (Shaw et al., 1993). More recently, TEM has provided additional evidence to suggest that a phloem restricted bacterialike organism (Plate 8) may be involved in yellow vine of cucurbits.

Grafting affected watermelon plants to healthy plants has been ineffective possibly because once the affected plant starts showing symptoms, it does not live long enough to establish a good graft. Dodder (Cuscuta sp.), attached to healthy watermelon plants in plastic pots, appeared to be killed within 7 days after being wrapped around symptomatic watermelon plants. Conversely, dodder wrapped around healthy watermelon plants established a parasitic

relationship within 3-4 days and proliferated. Graft transmission and dodder transmission of a BLO has been reported in strawberry with similar negative results in France (Naurrisseau et al., 1993).

The pathogen which causes yellow vine of cucurbits has not been isolated nor positively identified despite being subjected to a vast array of diagnostic techniques. Perhaps the only conclusive information we can offer at this point is that yellow vine is not caused by a virus or mycoplasma, nor is it likely due to any recognized fungal pathogen. The best evidence to date is the association of a BLO with the yellow vine disease of watermelon, cantaloupe, squash, and pumpkin.

CONTROL

At present, there are no satisfactory control measures available. Weekly insecticide applications have provided some degree of yellow vine control in squash (Cartwright and Bruton, 1993a). Soil fumigation with methyl bromide has proven ineffective (Bruton et al., 1993). Disease incidence is greater when squash is grown using black and reflective mulches (Cartwright and Bruton, 1993). Note cover page which illustrates the death of plants on black plastic as compared to bare ground. If in fact yellow vine is vectored by an insect, it would be in direct conflict with other studies that have reported a reduction in insect vectored diseases using reflective mulches (Chalfant et al., 1977). Early planting in combination with black or reflective mulches has been disastrous for yellow vine control in cantaloupe, squash, and watermelon. Late or delayed plantings of watermelon and cantaloupe are generally not practical due to the price differential between early harvest vs. late harvest.

One potentially bright spot for the control of yellow vine is in the seedless watermelon. The triploid used to produce the seedless watermelon is typically planted in several rows with a diploid pollinator interplanted every fourth or fifth row. In several seedless watermelon fields in Texas and Oklahoma where yellow vine was detected, a high percentage of the diploid pollinator plants had symptoms of yellow vine whereas the triploid never exceeded 5%. The seedless watermelon industry in the United States accounted for about 10% of the watermelons sold in 1994 as compared to less than 1% in 1986 (American Sunmelon, personal communication).

CURRENT AND FUTURE RESEARCH

Current yellow vine research consists of a multidisciplinary team that includes geneticists, plant pathologists, and entomologists. The work is conducted in cooperation with scientists and extension personnel from Oklahoma State and Texas A & M Universities. The following are descriptions of the research in each discipline:

I. Pathology - Dodder transmission remains a high priority to establish proof that yellow vine is caused by a bacterialike organism. Additional work on host range and planting date are underway. Work on development of a DNA Probe is in the initial stages. If the DNA Probe work is successful, surveys will be made to determine the insect vector and reservoir host. With this information, control strategies can be implemented.

II. Entomology - Entomological research focused on identifying the yellow vine insect vector, and evaluation of integrated pest management strategies that are designed to control insect pests before they attack cucurbit crops.

III. Genetics - The seedless watermelon has consistently proven to be resistant or tolerant to yellow vine. Studies have been implemented to quantify the disease reaction of the seedless watermelon in comparison to the diploid pollinator. The possible genetic implications will also be evaluated.

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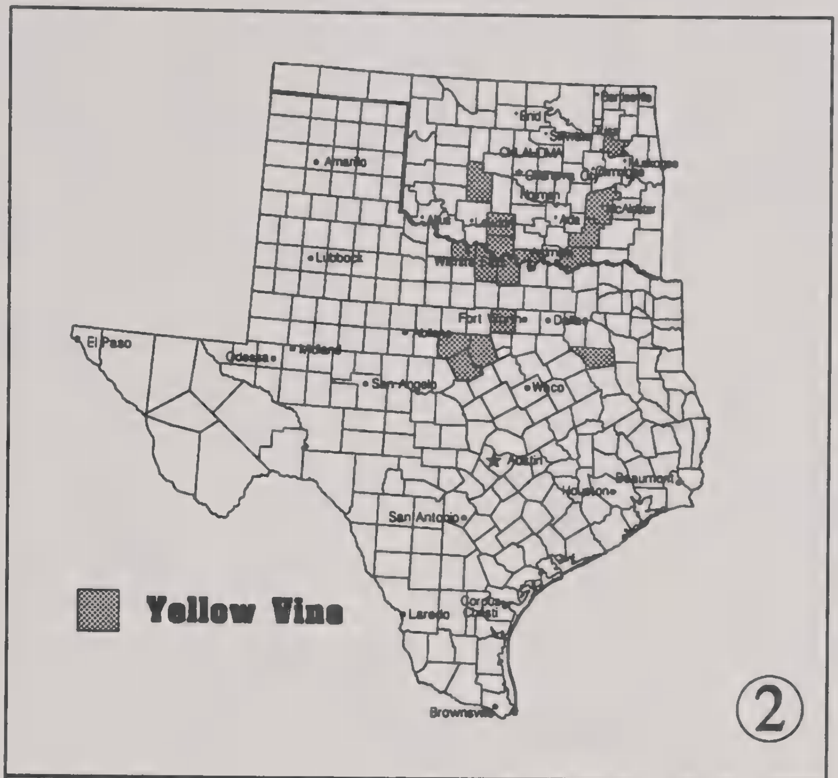
COMMON NAME	CAUSAL AGENT	VISUAL ROOT SYMPTOM	STEM GUMMING	ABOVE-GROUND CROWN LESION CHARACTERISTICS	COLOR OF * CROWN LESION	FRUITING STRUCTURES	COMMENTS
CHARCOAL ROT	Macrophominia phaseolina	None	Yes	Profuse gumming; small sparse fruiting structures	Greenish (watersoaked)/Tan	Microsclerotia/ Pycnidia occasionally	Most common vine decline in some geographical areas.
GUMMY STEM BLIGHT	Didymella bryoniae	None	Yes	Profuse gumming; large, profuse fruiting structures	Greenish (watersoaked) with numerous black fruiting bodies/Tan	Pycnidia/ Perithecia	Predominant vine decline of cantaloupe in some hybrids.
MONOSPORASCUS ROOT ROT/VINE DECLINE	Monosporascus cannonballus	Brown Root Rot	No	None	None	Perithecia	Has become a prominent vine decline in many semi-arid areas.
ACREMONIUM COLLAPSE	Acremonium sp.	Brown Root Rot/Corking/ Root distortion	No	None	None	None	Causes seedling disease and mature vine collapse (California and Spain).
YELLOW VINE	(Possible ?) Bacteria Like Organism	None	No	Leaves turn yellow quickly as fruit mature	None	None	Cross-section of crown shows phloem discoloration.
FUSARIUM WILT	Fusarium oxysporum f.sp.melonis	None	Sometimes slight	None, sometimes elongated on one side of stem	Dark Brown/ Dark Brown	None	Cross-section of crown shows xylem discoloration.
PURPLE STEM	Phomopsis cucurbitae	None	Yes	Smooth, not cracked sparse gumming	Purple/white	Pycnidia	Lesion changes color from purple to white with age. Infrequent occurrence.
LASIODIPLODIA DECLINE	Lasiodiplodia theobromae	None	Yes	Profuse gumming large, sparse fruiting structures	Greenish (watersoaked)/Tan	Pycnidia	Least common vine decline.
MYROTHECIUM CANKER	Myrothecium roridum	None	No	Sunken canker; abundant visual fruiting structures	Greenish Black/Black	Sporodochia	Causes quick death of plant if girdles stem. Infrequent, primarily following heavy rains.

*Color of young lesion/color of old lesion

Fig. 1. Chart of diagnostic characteristics for vine decline diseases of cantaloupe.



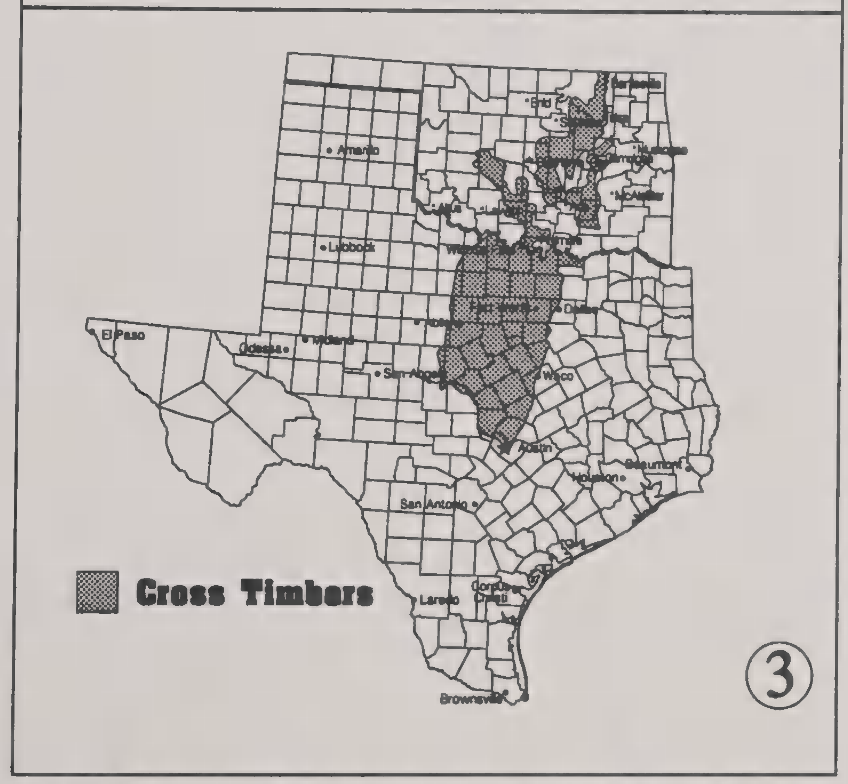


Fig. 2. Shaded area represents counties positive for yellow vine.
Fig. 3. Shaded area represents Cross Timbers vegetational area.